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# ERRATIC AND SYSTEMATIC GRADING OF PIG IRON BY ANALYSIS.

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In this paper it is intended to call attention to the present rather erratic methods adopted in grading pig iron by analysis, and to deduce principles whereby standards for such grading could be established. In this way a fair idea could be formed in regard to the physical properties which may be expected from different brands of pig iron, wherever they are referred to by numbers. The erratic and unsound manner in which the grades of different brands of pig iron are now numbered cannot be better brought out than is done in the recent book entitled "Analyses of Pig Iron," by Mr. Seymour R. Church. In this work, we find pig irons called No. 1 by their makers and ranging in silicon from one-half of one per cent. (.50) to four per cent. (4.00), furthermore the wildest kind of confusion as to numbers and trade marks, etc., supposed to designate the special qualities of the different grades of pig iron reported.

The distinction between the terms "brand" and "grade" of an iron may be stated to mean that a "brand" is supposed to possess chemical or physical properties not met with in their entirety in another kind of iron, while the "grades" of an iron are the different degrees of hardness obtainable from any special brand when run into similarly shaped castings.

To illustrate the present impracticable and meaningless habit of numbering grades of pig iron when grading and selling by analysis, the writer presents a chart, Fig. 1. Every line stands for a range of one-fourth of one per cent. in silicon in the composition. The length of the heavy black lines represents the relative number of analyses giving the different percentages of silicon in irons called No. 1, as found in Mr. Church's work. Coke irons are

shown on the left and charcoal irons on the right. It is to be understood that this paper is not a criticism on the book "Analyses of Pig Iron," but rather on the absence of method and standards in such a grading of pig irons by analysis.

No. 1 Irons.

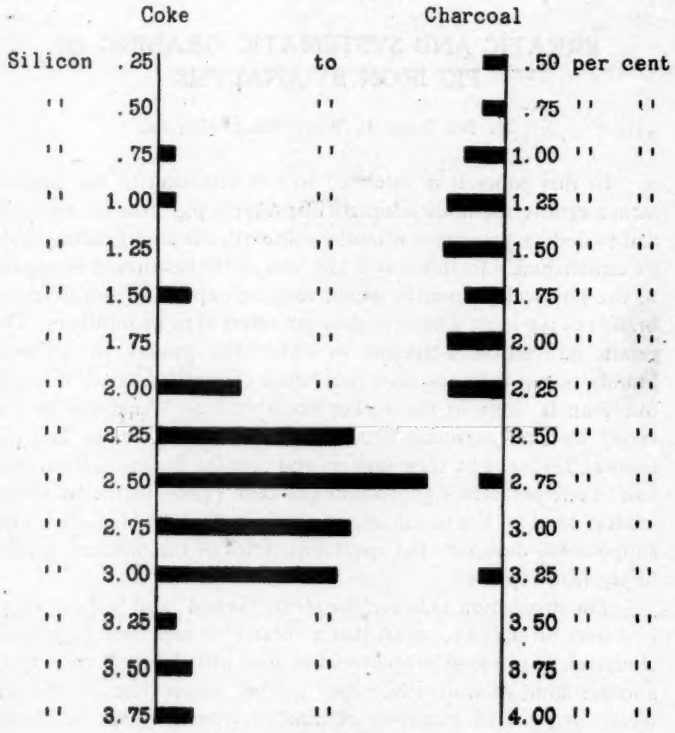


**Chart showing erratic grading of Pig Iron in 1900.**

**Fig. 1.**

The general conception by foundrymen of a No. 1 pig iron is that it refers to that grade of iron which is best adapted, when melted by itself, to give soft iron in castings ranging from 1 inch thickness down to stove plate. Then again, genuine No. 1 iron is more expensive to make than a No. 2 or 3. This is due to the

fact that a No. 1 iron must contain more silicon than a No. 2 or 3, and the higher the silicon, the more fuel is necessary to make it. When we read the market reports of pig iron prices we generally see them quoted as No. 1, No. 2, No. 3, etc. If one furnaceman calls an iron containing but .50 per cent. of silicon a No. 1 iron and another calls a 4.00 per cent. silicon iron No. 1, what is one to understand by such terms, and what endless confusion and loss must not such a practice cause?

The writer has stated in other publications that there is no really bad iron, meaning that there is a market for all brands and grades of pig iron. This being accepted, it cannot profit any furnaceman in the end, to intentionally dispose of iron to a customer which may not be best suited for his work. Furnacemen are not the only ones to blame when their customers receive iron not suited for their purpose. Unfortunately too few buyers know what they should use, and hence, between the two, there is much to be remedied. However, the writer looks for the day when almost if not all irons will be shipped just where they will do the work they are best suited for. This cannot be fully realized until furnacemen will not only furnish chemical analyses as they now do, but also physical tests of their pig iron after it has been remelted in a small cupola. These physical tests should give the strength, deflection, contraction, chill, and fluidity of their pig irons, as obtained by a practical and standard system of testing. The data derived from such tests would not only show up the difference in the various brands of iron, but would also enable users to obtain the grades (by a uniform or standard system of numbering these) in any special brand which will best suit their requirements.

All progressive furnacemen and founders now work under the rule that silicon and sulphur are the elements which control the grading of iron by analysis, ores, flux, and fuel being similar This principle was first advocated by the writer in his work "Metallurgy of Cast Iron." It also allows the devising and establishing of standards in grading pig iron by analysis which can be adhered to by all furnaces making irons ranging from .50 to 3.00 per cent. in silicon. The line of distinction between grades should be drawn so that the amount of silicon and of sulphur which can make a perceptible change in the hardness of castings when pig iron only is remelted is taken into account.

The writer's extended experience obtained by closely following variations in the hardness of castings due to changes in silicon and sulphur, is such that he can safely say that where sulphur is kept constant, every increase of .25 per cent. in silicon should change the grade of pig iron one number in all iron ranging up to 3.00 per cent. in silicon.

It takes less sulphur than any other element to effect a change in the grade or hardness of a casting. A change of one point of sulphur (.01 per cent.) can neutralize the effect of eight to twelve times the amount of silicon. This will be better understood by reference to Table 1, which shows approximately the increase in silicon and sulphur necessary to maintain a uniform hardness (or a constant condition of the carbons) in remelted pig iron. This can only be observed by melting pig iron in a cupola at the furnace or in the foundry, to make test bars or castings. In brief, Table 1 shows that if an iron containing 2.00 per cent. silicon should have its sulphur increased from .01 to .06, that in order to maintain an approximately equal hardness in similar test bars or castings, the silicon would have to be increased .50 per cent.

TABLE I.

| | | | | | | |
|---|---|---|---|---|---|---|
| Sulphur | .01 | .02 | .03 | .04 | .05 | .06 |
| Silicon | 2.00 | 2.10 | 2.20 | 2.30 | 2.40 | 2.50 |

As a rule in coke irons the lower the silicon the higher the sulphur. In establishing standards the amount of sulphur, therefore, should be considered as well as the silicon. Recognizing this fact in connection with the statement given above, which makes a distinction in grade at every .25 per cent. of silicon, Table 2 is presented for consideration in discussing standards for the numbering of grades. One may thus form some fair idea of the hardness to be expected in castings from pig iron when ordering No. 1, 2, or 3 in different brands of iron.

TABLE II.

| | No. 1. Iron. | No. 2. | No. 3. | No. 4. |
|---|---|---|---|---|
| Silicon | 2.75 to 3.00 | 2.50 to 2.75 | 2.25 to 2.50 | 2.00 to 2.25 |
| Sulphur | .01 to .02 | .01 to .03 | .01 to .03 | .01 to .04 |
| | **No. 5.** | **No. 6.** | **No. 7.** | **No. 8.** |
| Silicon | 1.75 to 2.00 | 1.50 to 1.75 | 1.25 to 1.50 | 1.00 to 1.25 |
| Sulphur | .02 to .04 | .02 to .05 | .03 to .05 | .03 to .06 |
| | **No. 9.** | **No. 10.** | | |
| Silicon | .75 to 1.00 | .50 to .75 | | |
| Sulphur | .04 to .07 | .04 to .10 | | |

Numbering the grades from No. 1 to No. 10, advancing in silicon .25 and sulphur .01 to .03 or more in each grade, as shown in Table 2, gives a range that may be said to include all the necessary ones that are now used in making castings, except the so-called softeners or ferro-silicons. It will be noticed that the suggestions for grading pig iron as given herewith arbitrarily starts with No. 1, an iron containing from 2.75 to 3.00 per cent. of silicon. The majority of furnacemen happen to grade pretty closely to this standard, as is shown by Fig. 1, which gives the greatest numbers of irons graded as No. 1 as containing 2.50 to 2.75 per cent. in silicon.

When purchasing ferro-silicons or softeners, their exact composition should be obtained, as indeed should those of any grades in No. 1 to 10 irons given in Table 2, so that when using any of the grades by these tables they could be handled intelligently and give the founder exactly or very closely the quality desired in his castings.

The phosphorous, manganese, and carbon contents, it will be noticed, is not touched upon in any of the above tables. These are ingredients which are fairly constant in all brands of iron made from similar ores, fuel, and fluxes, and what slight changes may occur in them can affect the grade of any brand of iron very little. While this is a fact, it would generally be advisable for furnacemen in advertising their irons to state along with the brands named, what per centage of phosphorous and manganese and in some cases, total carbon, their iron contain, as there are conditions demanding varying per centages of these elements met with that would enhance the irons were these points made known. As for example, a founder making very thin castings would require higher phosphorous, which gives more fluidity to iron, than is available in some regular No. 1 grades. Then, again, it is often necessary to know what manganese an iron contains, as when it is more than .50 its influence is to harden. With regard to the carbon, the "total" is all that is generally required. Giving the per centage of what is combined or free carbon in iron tells nothing further than the melting qualities of the metal. In this the more the carbon is combined, the easier or quicker the iron melts, a fact discovered by the writer several years ago and confirmed by Dr. R. Moldenke, by further experiment. If a knowledge of the combined or graphitic carbon contents of pig iron was

of any real value in grading pig irons by analysis, grading could be done effectively by fracture or hardness and the only determinations required would be those of the total carbon, phosphorous, or manganese, accordingly as information might be desired of one or all of these ingredients.

By bringing forward the suggestions herein outlined for grading pig iron by analysis, a way is opened up whereby it is hoped that much good will result. This is a good subject for discussion by furnacemen as well as founders and would be adapted for further ventilation at the coming convention of the American Foundrymen's Association where the greatest number of those interested would meet. The work of this association in helping to bring about greater uniformity in the chemical analysis of irons by preparing standardized drillings (now in use in nearly two hundred of our leading laboratories), also in testing the various grades of cast iron is recognized as having been productive of much good. It therefore seems to the writer that this same association could also exert a beneficial influence in bringing about greater uniformity in the grading and selling of our foundry irons.

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